

Express Mail Certificate No. EL 120 541 008 US

PATENTS
PD-99W075

Jc841 U.S. PTO
09/636100



MULTICOLOR STARING MISSILE SENSOR SYSTEM

Mary Dominique O'Neill
William Hale Wellman

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MULTICOLOR STARRING SENSOR SYSTEM

This invention relates to a sensor system, and, more particularly, to a sensor system used to detect threats posed by missiles fired at an aircraft.

BACKGROUND OF THE INVENTION

5 Missiles fired at aircraft are usually guided either by a light seeker or by radar. Of the various types of seekers, infrared light seekers pose some of the greatest problems to aircraft defense. Unlike radar seekers, infrared seekers are passive and do not emit a detectable signal prior to the firing of the missile. Pilots therefore have little warning of their presence prior to the firing of the missile.

10 Infrared-guided missile systems are relatively inexpensive, and human-portable units are widely available.

There has been a continuing effort to develop sensor systems that are carried on aircraft and are used to detect missile threats, particularly infrared-guided missiles. The sensor system must be effective to detect the infrared signature of a relatively small-sized missile at as great a distance as possible, in order to give the pilot the greatest time to take evasive action or to trigger countermeasures. In one approach, a wide-angle, two-color staring sensor system has been suggested to be particularly effective in detecting threats. This approach uses a two-color "sandwich" detector in the sensor. The technology of such a two-color detector is complex, still under development, and expected to be relatively expensive when finally perfected. Additionally, it is expected to have limited resolution, sensitivity, and clutter-rejection capability, particularly when mounted on a fast-moving aircraft platform where there is a tendency for digital images to be smeared in some viewing orientations.

25 There is an ongoing need for an improved approach to a sensor system for
use in an aircraft, particularly for detection of missile threats. The present
invention fulfills this need, and further provides related advantages.

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having an imaging detector array, which converts incident light energy into an electrical signal. The detector has a first-color region and a second-color region. A first-color imaging system comprises a first-color filter positioned between the scene and the first color region of the detector, a first-color optical train that
5 focuses first-color scene energy onto the first-color region of the detector, and a first-color optical fiber bundle having a first-color input end that receives the first-color scene energy from the first-color optical train and a first-color output end that directs the first-color scene energy onto the first-color region of the detector. The first-color optical fiber bundle comprises a plurality of first-color optical
10 fibers wherein each of the first-color optical fibers has a first-color fiber input shape and size at its first-color input end and a first-color output shape and size at its first-color output end. The first-color output shape and size are different from the first-color input shape and size. A second-color imaging system comprises a second-color filter positioned between the scene and the second-color region of the detector, a second-color optical train that focuses second-color scene energy onto the second-color region of the detector, and a second-color optical
15 fiber bundle having a second-color input end that receives the second-color scene energy from the second-color optical train and a second-color output end that directs the second-color scene energy onto the second-color region of the detector. The second-color optical fiber bundle comprises a plurality of second-color optical fibers wherein each of the second-color optical fibers has a second-color fiber input shape and size at its second-color input end and a second-color output
20 shape and size at its second-color output end. The second-color output shape and size are different from the second-color input shape and size. The additional and/or preferred features described above for the single-color sensor system may be provided with either or both imaging systems of the two-color sensor system. Additional color imaging systems may be added if desired. The detector may instead be a flat-plane configuration in which the colors are superimposed in a
25 "sandwich" geometry.

30 The present approach thus provides a single-color or multicolor (two or more colors) staring sensor system. It may use a single detector, even for multicolor sensors, which simplifies the problems of image physical registration and time registration. There is good resolution as well as good sensitivity and

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Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention. The scope of the invention is not, 5 however, limited to this preferred embodiment.

Figure 1 is a schematic system diagram of the sensor system;
Figure 2 is perspective view of an optical fiber in an optical fiber bundle;
10 Figure 3 is a schematic depiction of nonlinear mapping of the fiber optic pixel structure to the detector array pixel structure; and
Figure 4 is a perspective view of a packaged lens and detector assembly.

Figure 1 depicts a sensor system 20 for viewing light energy from a scene. The sensor system 20 includes a detector 22 which converts incident light energy into an electrical signal 23. The detector 22 preferably comprises an imaging digital focal plane array (FPA) sensitive to a selected wavelength or range of wavelengths of interest. The primary interest of the inventors is light in the infrared, and the detector 22 is sensitive to light in that range. Imaging detectors 22 operable in the infrared are known in the art. In a common case, the imaging detector 22 has a 512 x 512 detector array of pixels.

In a preferred embodiment, the detector 22 has a first-color region 24 and a second-color region 26. As will be explained in more detail, this preferred embodiment is a two-color sensor system 20. The desirability of using two colors in sensor systems is known in the art, but the present approach provides an advantageous way for implementing the two-color approach. The present approach is operable with any pair of colors within the range of the detector 22, and the selection of the two specific colors to be analyzed is not a part of the present invention. If instead the sensor system 20 is a single-color embodiment,

5 The sensor system 20 includes a first-color imaging system 28 comprising a first-color filter 30 positioned between the scene and the first-color region 24 of the detector 22. A first-color optical train 32 focuses first-color scene energy onto a first-color input end 38 of a first-color optical fiber bundle 36 of the first-color region 24 of the detector 22. The first-color optical train 32 is formed of lenses and/or mirrors that achieve the desired focusing of the first-color scene energy. 10 Such lenses and/or mirrors are selected according to established optics principles. In the illustration, the first-color filter 30 is positioned between the first-color optical train 32 and the first-color optical fiber bundle 36, but that need not be the case and other operable positioning may be used.

One of the first-color optical fibers 42 is illustrated in Figure 2. (This description is applicable to the single type of optical fiber in a single-color sensor system and the multiple types of optical fibers in a multi-color sensor system, as well.) Each of the first-color optical fibers 42 has a first-color fiber input shape and size, numeral 44, at its first-color input end 38a and a first-color fiber output shape and size, numeral 46, at its first-color output end 40a. The first-color fiber output shape and size 46 are different from the first-color fiber input shape and size 44. In the embodiment of Figure 2, the first-color fiber input shape 44 is substantially rectangular with a ratio of length to width of about 8:1, and the first-color fiber output shape 46 is substantially square with a ratio of the sides of about 1:1. The first-color input size is accordingly about 8 times that of the first-color output size. The first-color optical fibers 42 are thus tapered from the larger input end 38a to the smaller output end 40a. The advantages of this transformation of pixel shape as used with a spatial reorientation, such that a typical square pixel

The rectangular shaping of the first-color optical fibers 42 achieves improved resolution in one dimension to maximize the sensitivity of the sensor system 20. Because the potential target (e.g., a missile) in the scene and the resulting image has a small spatial extent, clutter rejection is achieved by spatially filtering objects in the image that are larger than the potential target. Ideally, then, the resolution cell is no larger than the maximum potential angular size of the potential target. However, small square fiber input shapes, the usual approach in pixilated images, would require a larger focal plane array detector than is achievable at present for a wide field-of-view system. In addition, this resolution would be better than the hand-off accuracy that is required. By creating larger rectangular collection elements at the input end, the required high spatial resolution is achieved with fewer pixel elements than would otherwise be required. The angular accuracy of the sensor system 20 is determined by the long dimension of the input end 38a of the optical fibers, while the resolution for target spatial matched filtering is determined by the narrow dimension. In an example, assuming a 512 x 512 pixel focal plane array and a 120 degree field of view, the accuracy is 11.6 mradians (milliradians) and the resolution is 1.45 mradians.

25 The pixels that are defined by the first-color input end 38a of the first-color optical fibers 42 are mapped or directed onto selected pixels of the first-color region 24 of the detector 22. In conventional mapping practice, the pixels are mapped linearly. That is the (n,m) pixel of the scene is necessarily directed to the (n,m) pixel of the detector (where n and m are the row and column indices of each pixel). The present approach is a nonlinear approach wherein the (n,m) pixel of
30 the scene is not necessarily directed to the (n,m) pixel of the detector.

Figure 3 illustrates the preferred mapping approach applied to a specific case by way of illustration. This nonlinear mapping approach is selected to allow

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$$Y_F = 4(Y_L - 1) + n$$

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$$\begin{aligned} n &= 1 && \text{for } X_L \leq 256 \\ n &= 2 && \text{for } 257 \leq X_L \leq 512 \\ n &= 3 && \text{for } 513 \leq X_L \leq 768 \\ n &= 4 && \text{for } 769 \leq X_L \leq 1024 \end{aligned}$$

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The second-color optical fibers 62 are preferably tapered in the same manner as described for the first-color optical fibers 42. Figure 2 and the discussion of Figure 2 are incorporated as to the nature of the second-color optical fibers 62.

10 The mapping of the second-color scene energy pixels onto the second-color region 26 of the detector 22 follows the approach discussed above, which is incorporated here, except that X_F is offset by 256 to utilize columns 257 through 512 of the detector 22.

Figure 4 illustrates the physical packaging of the non-electronic portions of the lens/detector assembly 80 (that is, excluding elements 70, 72, 74, and 76) of the sensor system 20, in an application under development by the inventors. The lens/detector assembly is housed in a cylinder about 4-1/4 inches in diameter and 4-3/4 inches long. There are two viewing apertures 82 and 84, for the first-color imaging system 28 and the second color imaging system 48, respectively.

Although a particular embodiment of the invention has been described in detail for purposes of illustration, various modifications and enhancements may be made without departing from the spirit and scope of the invention.

Accordingly, the invention is not to be limited except as by the appended claims.

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